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TECHNICAL INFORMATION MEMORANDUM

ORGANIC CARBON NORMALIZATION OF SEDIMENT DATA

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1. INTRODUCTION

All sediment data collected in Washington State are evaluated using the Sediment Management Standards (SMS), Chapter 173-204 WAC. Under the SMS rule, the numerical sediment standards for most organic chemicals are organic carbon normalized. Consequently, all sediment samples that are analyzed for organic chemicals must also be analyzed for organic carbon to facilitate comparisons with the numerical standards.

This technical information memorandum describes why some sediment data are organic carbon normalized, how organic carbon data are collected and analyzed, provides an equation for organic carbon normalizing data, and explains how to evaluate historical data for which organic carbon data are not available. Finally, guidelines are presented for determining when it may not be appropriate to organic carbon normalize data.

For questions on the enclosed information or for further information, please contact the Sediment Management Unit at (SCAN 585)206/459-6824, or contact the NWRO or SWRO Sediment Technical Specialist.

2. WHY SEDIMENT DATA ARE ORGANIC-CARBON NORMALIZED

Concentrations of organic contaminants (particularly nonpolar, nonionizable chemicals) and the toxicity of these contaminants in sediments have been observed to correlate well with the organic carbon content of sediments (DiToro et al., 1991; Lyman, 1982; Roy and Griffin, 1985). Nonpolar contaminants in sediments or water preferentially partition into the organic material in sediments because of the similar chemical nature of the organic material to the nonpolar organic contaminants. Contaminants that form ions, such as acids, bases, phenols, and metals, do not partition as strongly into the organic fraction in sediments.

DiToro et al. (1991) and others have reported that the toxicity of nonionic organic chemicals in sediments appears to be correlated to the concentration of those chemicals in the organic carbon fraction of sediments, but is not well-correlated with the overall (dry weight) concentration of the chemicals in sediments. Therefore, the concentrations of contaminants in the organic fraction of sediments may be more relevant than dry weight concentrations for setting standards that are intended to prevent adverse biological effects.

In addition, because nonpolar organic contaminants are primarily associated with the organic matter in sediments, these contaminants move in the environment along with the organic fraction in sediments and may also move along with suspended organic matter in water. Therefore, gradients of chemical concentration associated with a source may be more easily observed when the data are OC-normalized than when they are presented in dry weight.

The Sediment Management Standards criteria for nonionizable organic chemicals have been set on an OC-normalized basis. Because the bioavailability of acids, bases, other ionizable organic chemicals, and metals are generally not controlled by organic matter in sediments, standards for these contaminants are set on a dry weight basis.

3. COLLECTING AND ANALYZING ORGANIC CARBON DATA

The organic carbon content of sediments is measured and referred to as *total organic carbon* (TOC). TOC refers to the total amount of organic carbon in the sediment, and does not include mineralized carbon present as carbonates or bicarbonates. These inorganic forms of carbon do not substantially affect the partitioning of organic chemicals, and are removed from the sample by the laboratory.

TOC samples may be collected in glass or plastic containers. A minimum sample size of 25 grams (wet weight) is recommended. Because a special bottle is not required, sediments for TOC analysis may be combined with sediments for other analyses that will be performed at the same laboratory. Samples should be stored frozen and can be held for up to six months if frozen.

Detailed methods for analyzing TOC samples may be found in the 18th Edition of *Standard Methods for the Examination of Water and Wastewater* (Franson, 1992). Method 5310B is recommended, slightly modified for sediment samples. A description of the method is attached as an addendum (*Clarification: Recommended Methods for Measuring TOC in Sediments*, K. Bradgon-Cook). The laboratory calculates the amount of carbon that was present in the sample from the amount of CO_2 released during combustion. TOC values are reported as percentage of the dry weight sample.

Nearly any full-service laboratory is equipped to perform this analysis, which costs approximately $60 per sample.

4. ORGANIC CARBON NORMALIZATION OF DRY WEIGHT DATA

As discussed in Section 5, organic carbon (OC) normalization is performed on a sample-by-sample basis, because TOC values vary from station to station. Because some site-specific evaluation is required (see Section 7), OC normalization should be performed by the project manager or consultant who receives data from the laboratory. Laboratories are generally not expected to perform the normalization.

To convert chemical concentration data expressed as mg/kg dry weight to mg/kg OC, divide the dry weight concentration by the percent TOC (expressed as a decimal), as shown in the following equation:

$$\text{mg/kg OC} = \frac{\text{mg/kg dry weight}}{\text{kg TOC/kg dry weight}}$$

where: mg/kg OC = milligrams of the chemical per kilogram of organic carbon

mg/kg dry weight = milligrams of the chemical per kilogram of dry weight sample

kg TOC/kg dry weight = percent total organic carbon in dry weight sample (expressed as a decimal; for example, 1% TOC = 0.01)

Although data are typically reported in mg/kg, data reported in ug/kg, ppb, or ppm can also be used in the above equation. For example:

$$\frac{\text{2 ug phenanthrene/kg dry sediment}}{\text{0.01 kg TOC/kg dry sediment}}$$

= 200 ug phenanthrene/kg TOC
= 200 ppb phenanthrene, OC-normalized.

Because this conversion is tedious to do by hand for large data sets, the data may either be entered into a spreadsheet or database that can be used to perform the conversion. **Contractors providing sediment data for permit applicants, cleanup proponents, or for Ecology should perform the normalization (for nonionic organic chemicals) and report the data for these chemicals both as dry weight and as OC-normalized data.**

5. TYPICAL TOC VALUES FOR SEDIMENTS

TOC values vary widely in the natural environment. A range of 0.5-3 percent is typical for Puget Sound marine sediments, particularly those in the main basin and in the central portions of urban bays. For example, the Puget Sound Ambient Monitoring Program reports a mean TOC value of 1 percent (PSAMP, 1990). TOC values less than 0.5 percent are commonly found in sandy or gravelly areas, erosional areas, or areas with fast-flowing currents (including rivers). In addition, the percent organic carbon in subsurface sediments usually decreases with depth, to as little as 0.01 percent.

Natural TOC values greater than 3 percent are common in nearshore environments. On occasion, natural TOC values of up to 12-15 percent have been observed in Puget Sound and other areas, particularly in depositional and/or quiescent areas where organic matter may collect. Natural TOC values may be much higher in marshy areas or other wetlands environments.

TOC values may also be artificially elevated in sediments that are heavily contaminated with organic substances (sewage, petroleum hydrocarbons, wood chips). Sewage and organic chemicals will typically raise TOC values by at most a few percent; in a majority of the cases, the effect will be negligible. However, organic debris such as wood chips can raise the TOC value by anywhere from several percent to 50 percent or more.

Because TOC values may vary widely within a single site, organic carbon normalization is preformed on a station-by-station basis. **Therefore, each sample that is analyzed for nonionizable organic contaminants must also be analyzed for TOC.**

6. EVALUATION OF HISTORICAL DATA SETS

Collection of TOC data is currently required for all sediment sampling to allow comparison to numerical sediment standards. However, many historical data sets are not OC-normalized and may not contain station-by-station TOC data. If any TOC data are available for the data set, it is recommended that a conservative value be chosen from the data available that represents the lowest percent TOC observed at the site. If different areas of the site appear to have widely varying levels of TOC, a different value may be chosen for each area that represents the lower end of the range of TOC values for that area. The professional judgment of the site/permit manager should be used to select an appropriate value in each case.

If TOC data were not included in the data set, data may be available from other studies in the same area. The SEDQUAL database may be consulted to determine whether TOC values are available for the area of interest. Again, a value should be chosen that represents the lower end of TOC values for the area, to insure that the OC-normalized concentrations calculated using the general TOC value are protective. If no TOC data are available for the area of interest, the Sediment Management Unit or a regional sediment technical specialist should be consulted to determine an appropriate TOC value to use for the comparison.

7. WHEN ORGANIC-CARBON NORMALIZATION MAY NOT BE APPROPRIATE

There are several situations, including those described below, in which it may not be appropriate to OC normalize sediment data. For additional information or guidance on data evaluation and presentation for these situations, contact the Sediment Management Unit or a regional technical specialist. **Because of the variety of uses to which sediment data are put, sediment data for nonionic organic chemicals should be reported both as dry weight and as OC-normalized data.**

In areas where the TOC is very low or very high, biological testing or use of dry weight concentrations should be considered along with OC-normalized concentrations in evaluating the extent of contamination and potential biological effects.

For example, if TOC values are very low (e.g., 0.1-0.2), it is even possible for background concentrations of organic chemicals to exceed the Sediment Quality Standards when OC-normalized. In this situation, it may be appropriate, on a site-specific basis, to use Apparent Effects Thresholds (AETs) expressed as dry weight (see PSEP, 1988) to evaluate sediment toxicity. Please contact the Sediment Management Unit for assistance in evaluating such data.

Conversely, if TOC concentrations in sediments have been increased above normal concentrations by organic contamination (such as wood chips, sewage, or petroleum), the OC-normalized values may be inappropriately low. In these cases, although the OC-normalized chemical criteria would not be exceeded, the sediments may still cause adverse biological effects and may therefore exceed the narrative standards or biological criteria. To address this concern, if the organic chemicals or substances that are the primary contributors to the elevated TOC levels are known, the contribution of the organic contaminants to the percent TOC may be determined through analytical methods and subtracted from the TOC value before OC normalizing. Alternatively, as described above, biological testing or dry weight AETs may be used to evaluate sediment toxicity.

Bulk sediment concentrations expressed as dry weight are used to make decisions regarding treatment and disposal of sediments. Currently, the Puget Sound

Dredged Disposal Analysis (PSDDA) program uses dry weight data to determine whether sediments can be disposed of in open-water disposal areas. In addition, upland disposal options require evaluation of whether the sediment exceeds land disposal restrictions and dangerous/hazardous waste thresholds, based on dry weight concentrations. For treatment alternatives, the average dry weight concentrations of chemicals in sediment may be used to predict the effectiveness of processes such as bioremediation or chemical stabilization/solidification.

8. REFERENCES

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